

BALANCING RISK AND OUTCOME IN PEDIATRIC CARDIAC ANESTHESIA

Mohammad Ali Sheikhi¹, Ahmad Ebadi^{2*}, Khosrow Sharifi¹

¹Assistant Professor of Cardiovascular surgery MD, Department of Cardiac surgery, Atherosclerosis Research Center, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

²Professor of Cardiac Anesthesiology MD, Department of Cardiac Anesthesiology, Atherosclerosis Research Center, Golestan Hospital, and Pain Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

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*Correspondence for Author

Ahmad Ebadi

Professor of Cardiac
Anesthesiology MD,
Department of Cardiac
Anesthesiology,
Atherosclerosis Research
Center, Golestan Hospital,
and Pain Research Center,
Ahvaz Jundishapur
University of Medical
Sciences, Ahvaz, Iran.

ABSTRACT

Up to date, pediatric cardiac anesthesia remains challenging and fascinating orientation of our expertise. Recent developments in pediatric cardiac anesthesia, relatively high- risk balance aspects of pediatric cardiac anesthesia by trying to improve heart recovery after surgery and the results are outstanding. Anesthetic techniques need to understand the effects of narcotics and particularly in the area of the heart bypass and surgery of children with heart disease. In this article, we will discuss the balance of risk and outcome of cardiac anesthesia in children.

KEYWORDS: Pediatric, Cardiac, Anesthesia, Effect, Heart, Risk, Outcome.

INTRODUCTION

Pediatric cardiac anesthesia has been a fascinating trend in our specialty, until now. The results of heart surgery in children have been rapidly improved, during the past 20 years. Even the most sophisticated methods, for example, HLHS (Hypoplastic left hearts syndrome) is associated with reasonable outcomes. Parallel to the advanced surgery, attempts to separate sick children in fastest time from oxygen are one of the main aims in anesthesia. Several studies show that rapid improvement method in adults will result same in child's heart. Especially the relief of

pain in children is one of the most important factors to exit successfully the tracheal tube (extubation), after the cardiac surgery (Romlin, 2013). Methods based on the classical postoperative narcotic (morphine often used) are associated with the risk of respiratory depression after anesthesia and it's the other side effects. Another important factor is reduction of stress after cardiac surgery. For this reason, efforts were done to introduce a regional anesthetic technique in pediatric cardiac anesthesia (Mittnacht and Rodriguez –Diaz, 2014). One of the concerns is the fact that pediatric cardiac surgery is mostly performed with extracorporeal bypass and systemic anticoagulation that may be a risk factor for example may causes epidural anesthesia. An interesting study of the adults' world was published in 2001 by Scott. et al (2001). In A & A, where they have reported some positive effects as a result of the relatively large number of patients, randomized studies of epidural techniques and extubation showed that investigated patients encountered with a reduced risk of lung infections and lower incidence of postoperative cardiac arrhythmias. But, the conducted study was criticized with some reasons. However, the study by Scott et al. (2001) initiated a lot of researches on the use of local anesthesia in cardiac surgery with encouraging results. So far its usage is still not common in adults as well as sick children. In several publications has been mentioned to Con's and Pro's controversial discussions about regional aesthesia in cardiac surgery (Ressia. et al, 2014). Pediatric cardiac anesthesia is complex and requires a high degree of specialization and still is an interesting trend in the field of anesthesia.

2. Method of anesthesia and its complications in children

Children are at greater risk of anesthesia in compared to adults. Most of the complications arise due to the overdose of anesthesia and/ or inadequate ventilation. Quite often, complications occur during the postoperative period. Therefore, it is recommended a special monitoring during the transportation of children from the operating room to the recovery room.

2.1. Hypoxaemia after surgery

The incidence of Hypoxaemia after surgery in children is very high. In a study that was performed by Xue et al. (1996), SPO₂ levels was less than 90% in 30% of the cases that were children at the age of less than 1 year old, 20% of the cases were children at the age of 1-3 year(s) old and 14% of the cases were children at the age of 14.3 years old. SPO₂ levels in many cases, was less than 85%. Hypoxaemia often happens after completion of anesthesia during postoperative period in recovery room. 100% of oxygen administration after

completion of anesthesia has no effect on the incidence of premature Hypoxaemia. Usually delayed in Hypoxaemia is associated with breath holding or crying, which reduced significantly with oxygen. Higher incidence of Hypoxaemia is along with following cases, intravenous induction, and application of muscle relaxants, tubing and duration of anesthesia for more than 1 hour. In the recovery room, acceptable level of PaO₂ is 80- 100 mmHg, which is related to 93- 97% of SPO₂. However, adequate oxygen of blood is not enough for tissues. Infection, hypotension, anemia, and CO- poisoning may prevent from presence of adequate oxygen in tissues. Supplemental oxygen should be applied in all high- risk patient or patient with the low SPO₂, (Zhu et al., 1996). The use of 100% of oxygen for a short period does not have a bad effect on the baby. Initial symptoms of oxygen toxicity can be seen after 72 hours.

2.2. Respiratory depression

Respiratory depression in children under general anesthesia can be strong due to the residual effect of anesthesia drugs. Mechanical factors such as stomach bloating or stomach tight bandage may also be responsible for such a complication.

High level of PaCo₂ is not always indicative of insufficient ventilation. Respiratory depression should be suspected when: (1) Tachycardia, shortness of breath, anxiety and hard ventilation associated with respiratory acidosis, (2) Hypercarbia reduces arterial pH < 7.25 or (3) PaCO₂ is gradually increased with a decrease in arterial pH. Postoperative respiratory depression is usually due to residual effects of muscle relaxants, intravenous or inhalants anesthesia drugs (Eriksson, 1999). Ventilation may be natural immediately after extubation but after a while, respiratory depression may be evident. Because there is no pain, anesthesia hangover from various agents may be revealed. Careful monitoring is necessary to reject such effects in the early recovery phase.

2.3. The emergence of delirium

Children more than the others are suffered from anesthetic complications, such as: confusion, delusion and uncontrolled activity. This can be seen most commonly in patients who have received potent inhalation anesthetic drugs (Keogh and Alexander, 2012). The postoperative pain, sensory deprivation (for example, eye dressing), residual effect of anesthetic agents and the other unfavorable environment are effective factors. Occasionally the hayperexcitable state remains for several hours, especially in patients with anxiety, who are not taking any medicine.

3. Total intravenous anesthesia (TIVA) in the pediatric cardiac anesthesia

Total intravenous anesthesia (TIVA), is useful for some cardiac injuries in children. And by improve in designing of the injection pump, it has became more practical, and also has became more suitable for children and so has received more clinical experiences. There are better understanding about Pharmacodynamics and Pharmacokinetics of intravenous anesthetic agents in the children under cardiopulmonary bypass (CPB) and the potentially beneficial effects of these factors (Anderson and Hodkinson, 2010).

3.1. Pharmacodynamic effects of anesthesia during surgery

Cardiopulmonary bypass with damages of correlate organs may be associated with both immediate and long- term effects. This damage can be associated with inadequate presentation of oxygen to tissues and also is associated with stress during the CPB and after it. Reduction of stress for the cardiac surgery in children and infants is associated with improved outcome after surgery (Laycock et al., 1992). Damages caused by presentation of inadequate oxygen and oxygen deficiency can reduce by metabolic depression by using of hypothermia and anesthetic agents. Such influences may be added, for example, cerebral metabolic depression induced by hypothermia, may produced by thiopental and/ or Propofol or Isoflurane during the CPB for preventing from EEG. Thiopental may cause reduce of brain damages. However, to avoid the EEG, a large amount of dose will be needed, which can produce hemodynamic instability, long- term effects of anesthesia, delayed extubation and increased sedation during the first few days after the surgery.

3.1.1. Cardiovascular effects of Propofol, Ketamine, and Narcotics

3.1.1.1. Propofol

Propofol has short life and sensitive tissue (context- sensitive half-time: CSHT), and when drug is given by injection, Propofol can significantly reduce adverse hemodynamic and metabolic effects of bypass and surgery. While creates rapid recovery and will be transferred to the postoperative care (Anderson and Hodkinson, 2010). Propofol reduces the amount of oxygen in whole body of adults during the hypothermic CPB (28°C), and reduces cerebral perfusion pressure, oxidative stress, cerebral blood flow, speed and delivery of microemboli. Propofol has also been shown to inhibit seizures and may act as free oxygen radical scavenger. Propofol during CPB causes a significant increase in venous saturation of mixed oxygen, significant reduction in systemic uptake of oxygen, average blood pressure during CPB, decreased in concentration of glucose and cortisol by difference in lactate

concentration, and the need for inotrope after CPB, and/ or during the recovery. Catecholamines and Cortisol are released during stress, which produce changes in microvascular permeability and damages some organs. These hormonal changes result in blood sugar, and leading to a worse neurologic outcome after brain ischemia. During the normothermia, Propofol can help prevent high sugar, produces rapid recovery and reduces stress (Laycock et al, 1992). Propofol can be used in patients at risk of long QT syndrome without increasing the risk of affliction to torsades (TDP). Propofol causes dilation of the arteries and veins in the systemic and pulmonary blood circulation. These effects will become prominent by concurrent use of vasodilators, such as alpha blockers, the phosphodiesterase 3 inhibitor, and angiotensin- converting enzyme inhibitors. These effects on blood flow can be modified by optimizing the intravascular disease period, surgical stimulation, increasing Propofol dose and change in rate of dose.

3.1.1.2. Ketamine

Ketamine is often selected for induction of anesthesia in patients with cyanotic condition, as systemic vascular resistance and the amount of cardiac output are increased, but without worsening of right –to –left shunt. This recent study was done randomly by Tugrul et al (2000). This study showed that Ketamine anesthesia with more stability in the cardiopulmonary condition, has been proposed before the Isoflurane anesthesia. Arterial oxygen tension, oxygen saturation and mean blood pressure were preserved at forwarded sternotomy in those patients who receives Ketamine. Ketamine does not increase the pulmonary vascular resistance in children with pulmonary hypertension.

3.1.1.3. Narcotics

Narcotics do not cause cordial depression and protects the heart by a mechanism. And therefore co- administration of the drug with every of Propofol and/ or with volatile drugs will produce double influence.

3.2. Preparation

Pharmacological agents can prepare exposure to the brain and heart diseases, stroke with chemicals and/ or can increase the bearing of nerve cells and heart cells against the fatal ischemic heart damage. Preparation with the volatile drugs and/ or injectable drugs may also be useful. Some of the volatile drugs which the most important ones is Isoflurane, when being used before the ischemic shock, are obtained for inducing of the ischemic tolerance in the brain and the spinal cord and also for perverting ischemia/ reperfusion (I/ R) of

myocardial injury. There are several mechanisms proposed for protection (for example, attenuation of calcium overloading, anti-inflammatory and anti-oxidant effects, preconditioning as protection). Preparation of anesthesia with volatile anesthetic improves the performance of recovery and decreases the amount of calcium after I / R. Clark et al (2008). Recently has shown in a study that a critical factor of repetitive injury of heart is mitochondrial permeability transition pores (MPTP). MPTP opening causes swelling of mitochondria with release of apoptosis protein and also causes mitochondrial oxidative phosphorylation. Consequently, the exclusion of ATP causes disturbance in ionic homeostasis and contractile function and eventually causes rupture and necrosis. Inhibition of MPTP opening during revascularization to heart protects from further damage. The represented Propofol for protection of heart against cordial shock is experimental in all kinds of models. These effects are attributed to their ability to act as a free radical scavenger through inhibition of calcium channels in the plasma membrane and to increase the antioxidant capacity of the tissue. Its antioxidant properties are responsible for the inhibition of MPTP opening in the Langendroff- Perfused Heart and its anti-apoptotic properties. The benefits of the antioxidant capacity of Propofol during the CPB, when using high maintenance dose (plasma levels of approximately 4.2 ng. ml⁻¹) was observed by Xia et al (2006). Propofol protect heart against I / R injury, given to its antioxidant effect and MPTP inhibition.

3.3. Pharmacokinetic anesthesia and heart bypass

During CPB, various factors act to alter drug situation and metabolism of body. At the start of CPB, bypass circuit, mixes a liquid with patient's blood. Mixing volume and its storage is different in about 1500 ml in adults and in about 350 ml in newborns. Such a mixture may be a crystal or mixed crystal with albumin and blood. This mixture is located between liquid bypass circuit and reduces patient's blood in the volume of packed red blood cells (Packed Cell Volume: PCV) of patient in to about 25%. The volume of plasma is increased to 40-50%. All these changes may alter the amount of protein in drug and its distribution. These results in decreased of total concentration of drug, are not always for free drugs. Potential changes in the balance of acid/ base during the CPB, will result in the change of concentration of ionized and non-ionized drug which is affect on the attached protein. The volume ratio of CPB circuit to the ratio of blood volume of patient for younger patients is more than in adults. As a result, such an effect in dilution of blood and its effect on proteins, the volume of distribution and release of drug may be pronounced in children against adults.

The mean of blood pressure by pumping speed and systemic vascular resistance can be determined by changing the use of vasodilators and vasoconstrictors. Distribution of blood flow and as a result drug distribution and metabolism of body can be different. Hepatic hypothermia and kidney enzymes are functions that influence metabolism of body for drug. Many drugs are attached to the components of CPB circuit (for example, Fentanyl).

There are significant developmental effects that should be considered on the composition of body (lipid and body's water), the size of body, the maturity of blood- brain barrier, distribution of blood flow, liver and kidney functions.

3. 3. 1. Propofol

Conflicting results have been obtained for Propofol. The total concentration of Propofol may increase in the free part at the beginning of CPB or may decrease the total concentration that may remain unchanged. Long – duration elimination of half- life has shown in a study, but redistribution of half- life was short. The concentration after drug stopping is rapidly declining and patients recover quickly. Generally, the free active concentration of these drugs remains unchanged but their action may be prolonged. In a prospective experiment from the accuracy and delicacy of target controlled injection (TCI) of Propofol in children which were employed data sets of Perfusor pharmacokinetic, children does not show significant change in PD (the level of consciousness), since, the volume of bypass circuit and the tank in contrast to the central volume and the other containers is small even in young children. For example, in a child that weight 10 kg, the volume of mixture will be 279 ml, while the volume in the main, the second and the third container will be 4600, 1340, and 8200 ml, respectively. Changes in this flow allows that the target of site to be impact on children (Mani and Morton, 2010).

3. 3. 2. Narcotics

All Narcotics show decrease in the total concentration of drug at the beginning of the CPB. The further degree of this reduction is with Fentanyl which in it, the substantial proportion of this drug adheres to the surface of CPB circuit. This reduction is minimized with those Narcotics that have high volume of distribution in a time that the mixture volume is low, and in those that can rapidly create balance to minimize the effect of dilution. CPB is associated with significant changes in the PK properties, for Alfentanil, Fentanyl, and Sufentanil (Narcotics that are under the biological evolution of liver and excretion). After the CPB, the elimination of the half- life of Fentanyl is prolonged, release of plasma is reduced and the volume of distribution is increased. It seems for Alfentanil that, CPB has a long elimination

in half- life and has increase in the volume of distribution, while the release of drug remains unchanged. The concentration of Alfentanil in all the CPB period remains relatively constant and the concentration of active drug remains unchanged. It seems that the kinetic of Remifentanil has minimal impact by unchanged CPB on the volume of distribution in a steady state, the volume of central container, and/ or elimination of half- life. The target of concentration effect of the site Remifentanil is typically used in the different TIVA. The target is sufficient in range of 2– 3 $\mu\text{g}\cdot\text{l}^{-1}$ for the laryngoscopy, in range of 6– 8 $\mu\text{g}\cdot\text{l}^{-1}$ for the laparotomy surgery, and in range of 10– 12 $\mu\text{g}\cdot\text{l}^{-1}$ for the stress related to the cardiac surgery. CSHT is defined as the time for reduce in drug concentration of blood plasma to 50%, after the injection and for maintaining of the stopped situation. CSHT is important when TIVA is also used. Fentanyl is a short CSHT when is applied by injection for a short time, but it increases as the duration of infusion is increased. The Alfentanil CAST is fixed after 90 minutes of infusion, (Table 1). Remifentanil versus sensitive background with a time deviation is independent from duration of injection due to its removing with the Esterase.

Table 1: The context- sensitive half- time (CSHT) of narcotics in children (Mani and Morton, 2010)

Time of injection (min)	10	100	200	300	600
Remifentanil	3-6	3-6	3-6	3-6	3-6
Alfentanil	10	45	55	58	60
Fentanyl	12	30	100	200	
Sufentanil		20	25	35	60

3. 4. Target- controlled Propofol injection

Total Intra Venous Anesthesia (TIVA) in children was studied in detail. TIVA can be submitted either by manually injection or by using of TCI (Target Controlled Infusions). TCI uses PK modeling to calculate bolus dose, and the rate of infusion to achieve the target, and/ or the user- defined concentration of blood effect. This can obtained with a controlled injection pump by a microprocessor, which includes PK modeling with appropriate parameters for age. The comparative studies between TCI and the manually injection show better hemodynamic stability, faster recovery with TCI, and low- dose of induction (Canstant and Rigouzzo, 2010).

3.4.1. Children Pharmacokinetic (PK) Model

There are several of PK model for the TCI devices which are used for children. Among them, Perfusor and Kataria are used more frequently. TCI with Propofol for most of models is

limited to the age of 3 years old or more. Recently, modified Perfusor allows to be used for babies by the age 1 year old and limitation weight of less than 5 kg. Paedfusor is a prototype system of developed TCI from a developed model by Schuttler that due to it the release proportional to the age is done. Release in children with the age of less than 12 years old (< 12), increases with decreasing of age (Mani and Morton, 2010). In the Paedfusor model the volume of central compartment and clearance have non- linear correlation with weight and the size of the central compartment in contrast with children models of Marsh and Schuttler. Thus, the user enters the weight and the age, and the pump automatically has entered the correct micro –constants into a three- part PK algorithm. The accuracy of Paedfusor system that was scheduled for cardiac procedures, was examined in 29 children aged from 1 to 15 years old (Constant and Rigouzzo, 2010). Anesthesia was presented by using Propofol which administered by Paedfusor. The accuracy of the system was examined by obtaining more than nine blood samples to measure the concentration of Propofol during the anesthesia and recovery. The forecast index of the average error performance and absolute performance error of Paedfusor system is much better than the ones that were discovered with adult Diprifusor.

3.5. Potential problems with Propofol

Propofol infusion syndrome is a metabolic disease that is usually associated with high dose, and/ or long duration time, and low carbohydrate uptake. With impairment of mitochondrial will be reduced fatty acid oxidation, and ATP production and as a result the long- chain interfaces of acyl- carnitine are produced. Propofol infusion syndrome can show body metabolism as an unknown metabolic, lactic acidosis, Rhabdomyolysis, heart failure, renal failure, and usually from high mortality. Compared with adults, higher concentrations of plasma and effect site are needed in children for induction of anesthesia. And to achieve to maximum effect and slower recovery from Propofol infusion takes longer. This creates potential problems such as excess fat and Propofol infusion syndrome, especially after a long heart surgery. A healthy child needs to 2-3 g.kg⁻¹.day⁻¹ of fat per a day that is equivalent to 4 mg.kg⁻¹.h⁻¹ of 1% Propofol in 10% of soybean oil. The excess fat can be countered by using of 2% Propofol, and/ or through the reduction of soybean oil from 10% to 5%, and/ or by using Propofol and some small actions such as a regional blockade, medicine, and/ or concomitant use of systemic Narcotics. By using TCI ends depth of anesthesia, and gradual reduce of injection. If possible, able to recover more quickly, it can reduce side effects in children (Mani and Morton, 2010). Propofol reduces systemic vascular resistance, which may worse the following cases: hemodynamic in patient with aortic stenosis, hypertrophic

obstructive of heart, Fallot tetralogy, left- right shunt, and/ or balanced blood circulation. Also, there is a significant gap in the PK model for some drugs, in using for sick children and for young children, newborns and infants, so cautious when using of these programs will be required for these ages. Future models will combine more complex algorithms than PK/ PD. Hence, when the method of TCI is used, anesthesiologist must still use their knowledge and experience, to determine the value of injection agents in influence on prevention of knowledge, pain and side effects (Mani and Morton, 2010).

4. Risk –equalizer and its consequences

The balance of risk and consequence can be observed as high risk/ low profit (undesirable), low risk/ low profit (required), low risk/ high profit (ideal), high risk/ high profit (careful consideration of value). The cases with low risk/ high profit can include topical anesthetic cream or larynx mask. Development of new offensive methods and/ or drugs with profound effects on body, often have potential risks and/ or even real risk in connection with their initial use that have been received to the safety range and absolute understanding. As a good example, the use of cardiopulmonary bypass (CPB) is for improving of the congenital heart defects.

Recent developments in pediatric cardiac anesthesia are balance aspects of relatively high – risk of cardiac anesthesia of children by trying to improve heart recovery after surgery and outstanding results. While heterogeneity of the disease's condition makes it difficult to present the result of prospective studies in one aspect or treatment; it is possible that by focusing on smaller studies, examines whether or not there is reasonable evidence or not. However, in a specialization that in the results are easily measured and compared in terms of mortality in entire of the units, there is a very conservative approach to change and to resistance for trying new techniques that may be at risk and high profit.

To move forward, this in the first stage of development for one or two units to become initiative and improve of the method, it is necessary to look at the evidence of benefit (or no) in a controlled manner before the widespread use of it. Resent examples of such an approach include rapid anesthesia of children, by using of the central neuraxial block, and postoperative management of newborns with hypoplasia of the left heart syndrome, is used. Rapid surgery of pediatric cardiac may seem fast with extubation in operating room and/ or a short time after that. Decades of 1980 and 1990 were performed with techniques for removal of stress by using of drug in high- dose and prolonged postoperative requiring ventilation

(Anand and Hiki, 1992). However, given to data that emerged from equipping benefits in the early of cardiac and non- cardiac surgery in adults, this issue is re-examined in children. Several cases of extubation techniques are pioneering not only for older children with open heart surgery but also for babies with more complicated surgery (Vricella and colleagues, 2000). In particular, clear data are emerged which are for some waste including the Fallot tetralogy, and surgery for ventricle physiology, some of the benefits of considering of hemodynamic and reducing the postoperative complications. The anesthesia techniques need to understand the effects of drug, especially in the field of bypass, and surgery for children with heart disease. One of the major efforts is effort to communicate the stress of anesthesia and the result of embryonic studies which are removed from uterus and are placed in bypass. Prescription of spinal anesthesia through the cistern, completely reduces stress of surgery and CPB and is associated with improve of survival unit after bypass. Recently, in adults, was performed a randomized study to evaluate the use of spinal morphine and bupivacaine during the surgery of heart, and this is compared with the method of Narcotics. The spinal group decreases stress with a higher cardiac index, pulmonary vascular resistance is reduced, and dysfunction of the postoperative atrial B-receptor is also reduced too, but the pulmonary become less and systemic vascular resistance is reduced in costs and the need for retractor is increased. High spinal anesthesia is also used in pediatric cardiac anesthesia for infants and small children undergoing the surgery with CPB (Pawade and colleagues, 2005). A group of high- dose Fentanyl, similar to the previous studies of Anand is compared with a group of high- dose spinal anesthesia by using static spinal catheter method. Spinal anesthesia was associated with decreased plasma norepinephrine and epinephrine concentration, interleukin-6, and the concentration of lactate in plasma in patients undergoing the prolonged CPB, while were shown differences in the other cardiovascular parameters. Lactate is decreased and interleukin (IL)-6 has a potential sign of benefit: Catecholamines are increased the expression of inflammatory cytokines such as IL-6, and a high concentration of IL-6, and serum lactate is associated with increased in complication of CPB in infants and children. Anesthesia management of the left heart syndrome hypoplasia has evolved over 20 years a part of the team process is yet continued. Such a high- risk activity in the left ventricle, aorta, and the mitral valves are underdeveloped, need for unusual ventilation and management of cardiovascular system to balance the systemic and pulmonary shunt. The right ventricle is fragile in neonatal period, particularly is needed for preservation of not only the pressure and related flow to the systemic circuit, but also to provide adequate pulmonary blood flow. In these patients, initially inotropic drugs can improve the haemodynamic value, but at the end,

can cause ventricular fatigue, energy substrates fatigue, and death. By using additional measures to assess cardiac output such as Near- Infrared Spectroscopy (NIRS), venous saturation, and non- invasive cardiac output helps to guide delicate balance in the management of postoperative. This situation is a good example of the necessity for the required immediacy action and it is understood that no one “is unfit for anesthesia and surgery” but that one is simply a question of assigning the individual risk and potential benefit to the planned method by individual.

The ratio of risk/ benefit is the selection of method that may not be immediately apparent. Especially if the benefits are not detected until the anesthesia is well timed out. In the past 20 years, very low major advances have existed in the understanding of the management of infants with their birth weight. The careful assessment of long- term neurological development over the years shows minor deviation of ideal physiological parameters during the care in the neonatal intensive care unit (NICU), which has profound effects that may not emerge until months or years later. Hypertension, hypocapnia, and/ or low oxygen concentration, and even a relatively short period of mild hypoglycemia, are along with the long- term significant results. In addition, ventilation mode has penetrated in the incidence and severity of pulmonary dysplasia and chronic lung diseases. It is obvious that the anesthesia management of these infants with low birth weight under closure of the ductus, requires a very high level of control for the purpose of minimizing the major deviations in the ventilation, controlling the blood pressure, and blood biochemistry in a limitation of surgery and anesthesia. These attendances include, the balance of concentration of inspired oxygen and saturation of blood oxygen through implemented changes by thoracotomy and pulmonary edema, the measurement and control of PaCo₂ and optimization of blood flow through the use of NIRS, ventilation control with neonatal ventilator instead of manually ventilated, and also maintain blood pressure control in all time. Do not worry, surviving is not enough: long –term phenomenon and quality of life, is important while is not considered in the terms of short anesthesia for ductal closure. This approach “accumulation of ultimate benefits” is a successful philosophy for high level of sporting benefits that need to translation of the complex medical environments, although the beneficial displays are much more difficult to prove than the competitive sports in the world.

5. SUMMARY AND CONCLUSION

The cardiac anesthesia in children including anesthesia of very young children with complex congenital heart disease, is for major surgeries. The unique nature such as population of patient requires considerable expertise and deep knowledge of changed physiology. Improved in the past few decades in this expertise has helped to the better protect and improves vulnerable patients.

The availability of new short- acting drugs, new concepts in modeling and computer and pharmacokinetics technology in pediatric cardiac surgery all have made possible the total intravenous anesthesia: (TIVA). There is better understanding from pharmacodynamics and pharmacokinetics from intravenous anesthesia agents in children under CPB. And the potentially beneficial effects of this method are now well understood.

While the heterogeneity of the disease condition, makes difficult to provide the results of prospective studies in one aspect or treatment, it may be by focusing on the smaller studies, investigate whether or not there is a reasonable evidence of value. However, in a specialized that in it the results are simply measured and compared in the term of mortality across the unites there is a very conservative approach for altering and resistance for examination of new techniques that may be at risk and high profit.

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